Title: The Physics of Auto Racing -- Cruising the Internet

Link to Outcomes:

- **Problem Solving** Students will determine a formula needed for cylinder capacity and a regression line for a scatter plot.
- **Communication** Students will identify and describe engine parts and functions to other students. Also, they will use telecommunications to exchange ideas with their peers.
- **Reasoning** Students will be able to follow logical scientific and mathematical directions and procedures.
- **Connections** Students will observe connections between physics, automotive technology, and mathematics. They will establish a relationship between bore, stroke, number of cylinders, and engine displacement.
- **Measurement** Students will measure bore and stroke.
- **Algebra** Students will collect, organize, and analyze data.
- **Geometry** Students will use formulas to calculate volume and displacement. Students will identify radius, diameter, and height of a cylinder.
- **Physics** Students will apply mathematic models to the solution of real-world problems.
- **Technology** Students will use telecommunications to access data. Students will use graphing calculators to create scatter plots and perform regression analysis. Students will learn the geometric properties of engines.
- **Cooperation** Students will demonstrate ability to problem solve cooperatively in the activity. Students will also work in teams on extension projects.

Brief Overview:

This learning unit is designed to give students a guided introduction to telecommunications for accessing data and guidance in the interpretation of that data. There are additional addresses provided to direct students to launching sites for collecting data into auto racing related independent research.

Grade/Level:

Grades 9-12: Physics/ Geometry/Algebra 1 or 2/ Pre-calculus

Duration:

This lesson will require a minimum of two block periods or three 50-minute periods. Extensions will require more time.

Prerequisite Knowledge:

Students must be familiar with the formula for the area of a circle. They should be able to use a graphing calculator to plot data and to perform regression analysis. (Note: The lesson can be adapted for use without technology if students can create a scatter plot and draw a line of best fit.) Students should also have experience with use of vernier calipers and rulers for measurement.

Objectives:

Students will be able to:

- define bore, stroke, and displacement.
- measure bore and stroke accurately.
- calculate displacement of an engine.
- browse given Internet addresses to locate data.
- create scatter plot of collected data.
- analyze data and determine mathematical model.
- discuss relationship using math model.

Materials/Resources/Printed Materials:

- Engine with cylinder head removed (or model)
- Vernier calipers
- Rulers
- Graphing calculators
- Computer with telecommunications software and link to world wide web
- Student Activity #1
- Student Activity #2
- Teacher Resource #1

Development/Procedures:

Lecture/Demonstration:

If possible, take the class on an inside school field trip to auto or power technology shop to view an actual engine block (with cylinder head removed). Otherwise, use a commercially available model of an engine or diagram. Have a knowledgeable student identify and explain the function of the block, pistons, bore, and stroke. Turn the crankshaft and ask students to observe the up and down motion of the pistons in the cylinders. Explain the definition of displacement.

Measurement and Calculation:

Working in cooperative teams, students will measure the bore (inches or cm) using a vernier caliper. Students will also measure stroke (inches or cm) using method determined by team and will calculate volume of cylinder using formula determined/found by team. Direct a comparison of team results and conclude by reviewing engine displacement as the total volume of the engine's cylinders. Develop the formula:

displacement = π(bore/2)^2*stroke*number of cylinders

Internet Data Search:

Students will access the Internet on computer and complete the Test Drive Activity worksheet (Student Activity #1) (See Teacher Resource #1 for sample model). Students access the DragNet link (http://chiller.compaq.com/dragnet/engines.html) and record bore, stroke, number of cylinders, and engine capacity for any 5 engines **with same number of cylinders (6 or 8)** listed (Student Activity #2) (See Teacher Resource #1 for Sample Data for Table 1). If Internet access is not available for an entire class, the data lists can be downloaded from the address given and replicated for student use.

Data Analysis/Conclusions:

Students compute the volume of one cylinder and record results in data table. Students create a scatter plot of Displacement vs. Cylinder volume. Students perform a regression analysis, writing the equation for the line of best fit, and the slope of the line. Students conclude by giving the meaning of the slope and a hypothesis for the relationship between engine capacity and horsepower.

Extension Projects:

- Write a program for TI-82 that will compute total engine displacement given bore, stroke, and number of cylinders.

- Design and race Lego cars powered only by elastic bands linked to gear wheels. For more information involving mass-to-gear ratio, torque, weight vs. acceleration, control in direction, and surface friction in wheels, cruise to address: http://www.lego.com

- Calculate tire pressure from car weight and area of tire contact patches.

- Perform kinematic analysis of accelerating vehicles.

- Execute model car drag races using CBL light probes to measure elapsed time and data analysis using formulas from DragNet. For lab write ups, contact edavis@pen.k12.va.us or gspieth@pen.k12.va.us.

Additional addresses and student research project ideas:

http://reality.sgi.com/employees/rck/PhOR/physics. faqs
description of 9 articles available about the physics of racing
http://yarrow.wt.com.au/~sjackson/racing.html
information on different games dedicated to auto racing
http://chiller.compaq.com/dragnet/weather.html
how weather effects performance in drag racing
http://chiller.compaq.com/dragnet/formulas.html
the relationship between car weight, net HP, and top speed
http://www.ccsbham.ac.uk/~bar/rars.ann
robot simulation races written in C++ of ANSI C
http://espnet.sportzone.com/editors/car/nascar/leader.html
latest standings : Winston Cup, Indycar, etc.
http://espnet.sportszone.com/editors/car/features/carbook0706.html
book review of The Open Road by Bert Levy
http://freenet3.sori.fsu.edu:81/users/indy500/Racing.html
a good launch site for more investigations

Evaluation:

- Question students on engine vocabulary.
- Check calculation of displacements.
- Monitor progress on use of Internet.
- Assess activity sheets.
- Grade extension project document/presentation.

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Student Activity # 1 Test Drive on Internet

Racing Team Members:_____

Directions: Locate each answer by cruising to the address given, and record each answer in the space provided.

1. Interpret the following expressions as they refer to drag racing:
   a. "Killing the tree" _____

   b. "He bulbed it away" _____

   address: http://www.bucknell.edu/~beard/drag/defns.html

2. a. When did balloon tires first appear? _____

   b. Define the term "trafficators." _____

   _____

   address: http:/ www.america.net/com/hotrods/hrhome.html

3. a. Define the term: cubic capacity._____

   _____

   b. What is the maximum engine capacity for Formula 1 racing? _____

   the maximum number of cylinders? _____

   address: http:// www.gnn.com/gnn/wic/sports.4l.html

4. Locate and record the following specifications for a Mazda Miata:

   bore _____ stroke _____

   number of cylinders ____ engine capacity _____

   address: http: //www.cse.ucsd.edu/users/paloma/miata/miata92.html

5. Using formula developed by the class for cylinder displacement and bore and stroke for the Mazda Miata, compute the Miata's cylinder displacement:_____.

   (Show all calculations below.)

Student Activity #2 BORES, STROKES, AND ENGINE CAPACITY

RACING TEAM MEMBERS:_____

address for data: http://chiller.compaq.com/dragnet/engines.html

1. Record in the table below: # cylinders, bore, stroke, and engine capacity for any five cars with the **same number of cylinders.**

TABLE 1

# cylinders	bore	stroke	engine capacity (cu. in.)	displacement of one cylinder
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

2. Compute the displacement of one cylinder of each car, and record in **TABLE 1**.

3. What are the constant(s) in **TABLE 1**? _____

4. What are the variable(s) in **TABLE 1**? _____

5. Enter all five displacements of one cylinder in L_1 (as x) and all five engine capacities in L_2 (as y) into a graphing calculator to create a scatter plot of the data.

6. Do regression analysis using the graphing calculator.

7. Record equation of best mathematical model below, including the correlation coefficient:

   MODEL:_____ Correlation:____

8. Record the slope of the line: _____, and describe the real-world meaning of the slope:_____

9. What is the relationship between the number of cylinders, the displacement of one cylinder, and the capacity of the engine?

10. Give a plausible explanation for the relationship between engine capacity and power.

Teacher Resource #1

Note: Due to the changing nature of information on the Internet, students may not be able to locate information at the addresses given on the worksheet. This activity is intended to be a model for directed Internet exploration. Teachers may need to create new questions applicable to information found at the addresses at the time the lesson is presented.

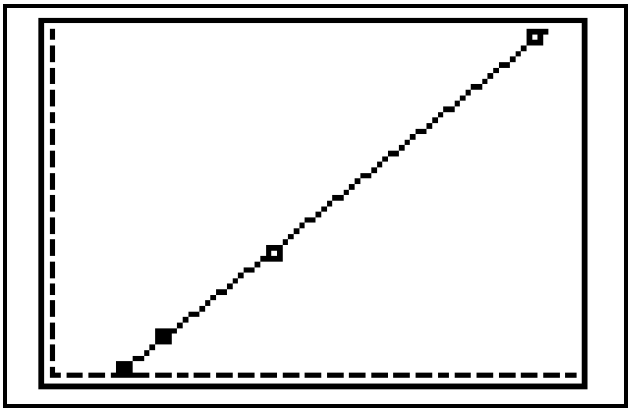
Solutions for ACTIVITY #1:

1a. the driver is getting great reaction times
 b. he redlighted or his car started before green light comes on
2a. 1923 Cole; Chrysler offered them on later selected models.
 b. mechanical arms that flipped out from the side of the car to indicate turning intention
3a. volume swept in the cylinder by the movement of pistons (cu. cm.)
 b. 3500 cc; 12
4a. bore = 3.07 in. stroke = 3.29 in. # cylinders = 4
 engine capacity = 97 cu. in.
 5. 24.35 cu. in.

Solutions for ACTIVITY #2: Sample Data for Table 1

# cylinders	bore in.	stroke in.	engine capacity cu. in.	volume of one cylinder
8	4.3	4.304	500.021919	62.503
8	4.3	4.06	471.674951	58.959
8	4.36	3.85	459.847232	57.481
8	4.313	3.9	455.830511	56.979
8	4.15	4.21	455.573189	56.947

Window: xmin = 55, xmax = 63, ymin = 455, ymax = 501



linear regression model: $y = 8x$ correlation $r = 1$

Slope indicates the number of cylinders in the car.

The volume of one cylinder multiplied by the number of cylinders equals the total displacement, and this is the engine capacity. If bore and stroke are measured in inches, the resulting engine capacity is measured in cubic inches. If the bore and stroke are measured in centimeters, the engine capacity is expressed in cubic centimeters.

Some discussion should include numbers of significant digits because the engine capacities given in Dragnet would indicate higher precision than is possible with the given bores and strokes.